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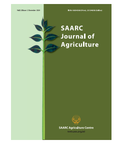


Research Article

# Evaluation of Different Chemical Insecticides and Biopesticides Against Vegetable Leaf Miner, *Liriomyza Sativae* in Tomato

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## Abstract

Vegetable leaf miner once considered as a secondary pest is now emerging as a primary pest of vegetables including tomato. It is also considered as an A1quarantine pest. Two experiments were performed to evaluate the efficacy of various insecticides against vegetable leaf miner in entomology laboratory and central farm of Sher- e- Bangla Agricultural University during October, 2019 to April, 2020. Seven insecticides such as Imidacloprid, Lamda cyhalothrin, Emamectin benzoate, Spinosad, abamectin, Matrine, azadirachtin at recommended dosages were evaluated to control vegetable leaf miner at both laboratory and field conditions. In case of laboratory experiment, treatments were evaluated using leaf dip technique in a completely randomized design (CRD) with three replications. In field study the treatments were laid in a completely randomized block design with three replications. Among all the tested chemicals and bio pesticides, Proclaim 5SG (Emamectin benzoate) @ 1.0g L$^{-1}$ water, Tracer 45SC (Spinosad) @ 0.4 ml L$^{-1}$water and Vertimec 018 EC (abamectin) @ 1.2 ml L$^{-1}$water were most effective against *Liriomyza* leaf miner in both conditions. Thus, three timely sprays of any one of these pesticides viz. Proclaim 5SG (Emamectin benzoate), Tracer 45SC (Spinosad) and Vertimec 018 EC (abamectin) at recommended dosages could be helpful to reduce the infestation of vegetable leaf miner.

**Keywords:** Vegetable leaf miner, insecticides, Laboratory evaluation, Tomato

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## Introduction

Tomato, being an important and widely consumed vegetable plays a crucial role in the nutritional status and livelihood of Bangladeshi people. Considering production, it is the fourth most produced vegetable in Bangladesh (BBS, 2020). But unfortunately, the susceptible nature of tomato plant to various kinds of insect pests hinders its potential production rate. Among the insect pests infesting tomato plants, highly polyphagous vegetable leaf miner *Liriomyza sativa* Blanchard belong to the family Agromyzidae is now appearing as a primary pest.

Seven species of genus *Liriomyza* have been recorded as economically important vegetable pest in Indonesia (Nonci and Muis, 2011) while in Bangladesh so far four-leaf miner species have been identified as crop pest (Mazumdar and Bhuiya, 2014). The tiny feeding and oviposition punctures made by adult female flies in the leaf surface develop a stippled and yellowish appearance to the infested leaves. After hatching inside the leaf, the newly formed larvae feed the mesophyll contents and proceeds forwards forming continuous mines which turns parchment white and affects photosynthesis. Tomato foliage may be lost up to 90% when uncontrolled population increase occurs (Schuster, 1978) while heavy infestation can cause up to 70% yield losses (Zoebisch et al*.,* 1984). As vegetable leaf miner is an A1 quarantine pest, besides direct damage producers also have to lose export markets. Even after withdrawal of complete bans, phytosanitary measures such as fumigation and irradiation are needed to be performed to fulfill the requirements of importing countries resulting in raised export costs (Reitz et al., 2013).

To cope with these problems tomato farmers, apply large quantities of broad-spectrum chemical pesticides with more frequencies. It is also notable that a pivotal part of the biology of leaf miner is its capability to develop resistance to insecticides (Parrella, 1987) resulting in failure of adopted chemical control measures of this pest. Thus, an ideal pesticide for effective management of vegetable leaf miner is one that is selective and considered safer than conventional pesticides for parasitoids associated with this pest or other natural enemies as well as has low toxicity to vertebrates. Most commonly used pesticides against Leaf miner were organophosphate, carbamate and pyrethroid insecticides but this pest has already gained resistance/tolerance against these groups (Reitz et al., 2013). Rapid failures of these groups of chemical insecticides have led to development of pesticides with new chemistries. Among the invented new groups, two translaminar novel larvicide abamectin (Avermectins) and spinosad (Spinosyns) from soil microorganisms are effectively used against leaf miner (Schuster and Everett, 1983). Neem extracts containing Azadirachtin are also proved effective against leaf miner as well as safe for natural enemies and surrounding environment. Recently another plant extract alkaloid matrine derived from roots of genus *Sophora* has high toxicity against various insect pests and can be efficaciously used to control leaf miner (Marcic et al*.,* 2012). It is worthy to mention that rotation among insecticides of various classes with different mode of action can delay the incident of resistance to any insecticide. In Bangladesh available information on management of leaf miner is not sufficient. Against this backdrop, the present study was undertaken to evaluate the effect of different pesticides with various mode of action on this obnoxious pest.

## Materials and Methods

The effect of various chemicals and biopesticides on vegetable leaf miner was evaluated in both laboratory and field condition.

### a) Laboratory Evaluation of Chemical Insecticides and Biopesticides Against *Liriomyza Sativae*

Leaf dip technique was used to evaluate the synthetic insecticides and bio pesticides at entomology laboratory, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during November, 2019 to January, 2020.Vegetable leaf miner infested leaves having 3rd instar larvae were collected from natural tomato field without spraying and placed in zipped polythene bag. To keep moisten inside the polybag, a soaked cotton piece was placed inside the bag. With the help of a sharp object few holes were made on the polybag to facilitate air circulation. The polybags containing infested leaves were brought in the laboratory to perform further investigation.

Each treatment solution was prepared using distilled water and applied at recommended dosages (Table 1).

Table 1. List of pesticides with recommended concentration

| Sl. no. | Trade name | Chemical name | Concentration |
|---|---|---|---|
| 1 | $T_1$ = Imitaf 20SL | Imidacloprid | 0.25 ml $L^{-1}$ water |
| 2 | $T_2$ = Fighter 2.5EC | Lamda-cyhalothrin | 1.0 ml $L^{-1}$ water |
| 3 | $T_3$ = Proclaim 5G | Emamectin benzoate | 1.0 g $L^{-1}$ water |
| 4 | $T_4$ = Tracer 45SC | Spinosad | 0.4 ml $L^{-1}$ water |
| 5 | $T_5$ = Vertimec 018EC | Abamectin | 1.2 ml $L^{-1}$ water |
| 6 | $T_6$ = Bikao | 0.36% Matrine aqua solution | 1.0 ml $L^{-1}$ water |
| 7 | $T_7$ = Dr. Neem | Azadirachtin | 0.5 ml $L^{-1}$ water |
| 8 | $T_8$ = Control | Distilled water | |

Collected leaves along with 3rd instar larvae were dipped into the prepared treatment solution for 5 seconds and placed separately on a paper for air drying. In case of control treatment, the leaves containing larvae were dipped into distilled water and air dried on a paper. The leaves were then kept in glass petridishes. For each treatment (10) ten 3rd instar larvae were maintained in a glass petridish. To keep moisten inside; the petridish bottom was covered with a water soaked tissue paper. The Petridishes were placed on a table at a room temperature, in a completely randomized design (CRD) with three replications. The leaves were examined at 24 hours intervals to ensure that there was no desiccation. Data on larval mortality was collected at 24 hours, 48 hours, 72 hours, and 6 days after application of treatment. The collected larval mortality data after 6 days of treatment application was converted into percent mortality and was corrected for untreated treatment (control) using Abbot's formula.

$$\text{Corrected mortality} = \frac{\text{\% test mortality- \% control mortality}}{\text{100 - \% control mortality}} \times 100$$

The number of pupa and adults of leaf miner were also recorded at the time of daily observation and their percentages were also calculated.

$$\text{Pupa formation percent} = \frac{\text{Number of formed pupa}}{\text{Number of taken larvae}} \times 100$$

$$\text{Adult leaf miner emergence percent} = \frac{\text{Number of emerged adult leaf miner}}{\text{Number of taken larvae}} \times 100$$

**b) Field Evaluation of Different Chemical and Biopesticides Against Vegetable Leaf Miner on Tomato**

This experiment was conducted during October, 2019 to April, 2020 using susceptible host plant tomato in the central farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka. The farm is located at $23^0 74^/$ N latitude and $90^0 35^/$E longitude with an elevation of 8.2 meter from sea level. The seeds of hybrid tomato KB1020 were collected from Bangladesh Agricultural Development Corporation (BADC) and seedlings were raised at the nursery bed of Folbithi Horticulture center, Asad gate, Dhaka following recommended methods. After final land preparation, the layout of the experiment was prepared by following Randomized Complete Block Design (RCBD) with eight treatments (same as in table 1) and three replications. Research layout was consisted of 24 plots each 2.5 m × 2.5 m in size with a 1.0 m distance between blocks and between plots. Fertilization was accomplished as per recommendation for tomato by BARI (2013).Thirty five days old healthy tomato seedlings were transplanted in the experimental plot maintaining 60 cm × 50 cm spacing. Various intercultural operations such as training of plants with rope, staking with bamboo, weeding, loosening the soil and irrigation were performed as per needed.

After calibration of sprayer, desired volume of spray solution prepared with tap water was sprayed by knapsack sprayer. Treatment application was started at the time of first appearance of damage symptoms and spraying was performed three times at 10 days interval. Prior to first spraying, data was recorded on different parameters to obtain baseline information. After each spraying data was recorded from five tagged plants plot$^{-1}$ on different parameters such as number of healthy plants, number of infested plants, number of healthy leaves plant$^{-1}$, Number of infested leaves plant$^{-1}$, number of larvae plant$^{-1}$and yield of the plot. Leaf infestation percent was calculated with the help of recorded data.

**Efficacy Percent**

Efficacy percent of experimented insecticides based on number of larvae leaf$^{-1}$ was calculated by using the following formula

$$\text{Efficacy percent} = \frac{\text{Precount} - \text{Post spray count (mean)}}{\text{Precount}} \times 100$$

Efficacy percent based on leaf infestation=

$$\frac{\text{Pre spray leaf infestation percent} - \text{Post spray leaf infestation percent (mean)}}{\text{Pre spray leaf infestation percent}} \times 100$$

**Results and Discussion**

**Laboratory Evaluation of Different Chemical and Biopesticides Against *Liriomyza Sativae***

**Effect on Larval Mortality Percent**

Larval mortality percent with various chemicals and biopesticides presented in Table 2 showed significant differences among the treatments over 6 days after treatment application. The highest mortalily was recorded on Tracer 45SC ($T_4$) with 96.26 % larval mortality as well as Proclaim 5SG ($T_3$) and Vertimec 0.18EC ($T_5$) both having similar percent value (88.88) while all three treatments were statistically similar. On the contrary, the lowest larval mortality percent (10.00) was observed in Control ($T_8$) followed by Bikao ($T_6$) and Dr. Neem ($T_7$) both having similar percent (48.14).

Table 2. Larval mortality, Pupal formation and adult leaf miner emergence percent of *L. sativae* in various treatments at different intervals in the laboratory condition

| Treatments | No. of tested larvae | Mean mortality percent after 6 days | Corrected Mortality percent after 6 days | Mean percent of pupal formation | Mean percent of adult Leaf miner emergence |
|---|---|---|---|---|---|
| $T_1$ (Imitaf) | 10 | 63.303 b | 59.25 b | 36.66 c | 26.66 bc |
| $T_2$ (Fighter) | 10 | 70.00 b | 66.66 b | 30.00 c | 23.33 c |
| $T_3$ (Proclaim) | 10 | 90.00 a | 88.88 a | 10.00 d | 6.66 d |
| $T_4$ (Tracer) | 10 | 96.66 a | 96.26 a | 3.33 d | 0.00 d |
| $T_5$ (Vertimec) | 10 | 90.00 a | 88.88 a | 10.00 d | 0.00 d |
| $T_6$ (Bikao) | 10 | 53.33 c | 48.14 c | 46.66 b | 23.33 c |
| $T_7$ (Dr. Neem) | 10 | 53.33 c | 48.14 c | 46.66 b | 33.33 b |
| $T_8$ (Control) | 10 | 10.00 d | 10.00 d | 90.00 a | 63.33 a |
| CV (%) | | 6.20 | 7.31 | 11.95 | 22.64 |
| LSD (0.05) | | 7.06 | 7.85 | 7.06 | 8.65 |

Same lettering in a column denotes statistical similarity among treatments whereas different lettering denotes statistically dissimilarity among treatments.

In case of larva to pupal formation, it was observed that the treatment Tracer 45 SC ($T_4$) resulted in the lowest percent of pupa formation (3.30) along with two statistically similar treatments Proclaim 5SG ($T_3$) and Vertimec 018 EC ($T_5$). This obtained result was close to Seal et al. (2002) who found no pupal formation for the treatment Abamectin. Considering larva to adult emergence, Tracer 45SC ($T_4$) and Vertimec 018EC ($T_5$) resulted in no adult emergence of leaf miner which were statistically similar with the treatment Proclaim 5SG ($T_3$). Contrarily, the highest number of leaf miner adult emergence (6.33) was observed in Control ($T_8$) followed by the treatment Dr. Neem ($T_7$).

Based on the above findings it can be summarized that Tracer 45SC ($T_4$), Vertimec 0.18 EC ($T_5$) and Proclaim 5SG ($T_3$) were most effective insecticides against *Liriomyza* leaf miner followed by Fighter 2.5EC ($T_2$) and Imitaf 20 SL ($T_1$). Some other researcher's findings (Reitz et al., 2013) were also pursuant to present work indicating the effectiveness of Abamectin and Spinosad against leaf miner larva while Ishaaya et al. (2002) reported emamectin benzoate as an effective insecticide against *Liriomyza*. According to Guntai et al. (2015) Abamectin was most effective against *Liriomyza* larva in laboratory while Imidacloprid was less effective than aforementioned one which was in agreement with the present result.

On the contrary, Bikao ($T_6$) and Dr. Neem ($T_7$) showed less effectiveness in causing larval mortality compared to aforementioned treatments which was supposed to due to their action mechanism as both are plant extracts. Approximately similar result was observed by Dimetry and El- Haraway (1995) in laboratory condition stating that the feeding deterrent activity of Neem seed kernel extract was significant against *Liriomyza* adults particularly at high concentrations while less effective against larva. According to Banchio et al. (2003) slow action of Azadirachtin allowed more leaf miner larvae to pupate which also justified the present finding regarding Dr. Neem treatment. Present result is also in line with the findings of Weintraub and Horrowitz (1997) indicating that the low concentration of azadirachtin had a minor effect on the larvae. On the other hand, as Bikao (Matrine aqua solution) was a new product used against *Liriomyza* larva in laboratory, it was not possible to relate its result with previous findings for want of information in published literature.

**Field Evaluation of Different Chemical and Biopesticides Against *Liriomyza Sativae* on Tomato**

Among all the tested treatments the lowest number mean no. of larvae leaf$^{-1}$ with 1$^{st}$ spray was observed in the treatment $T_5$ (Tracer 45SC) followed by treatments $T_6$ (Vertimec 018EC), T3 (Proclaim 5SG) and $T_8$ (Dr. Neem) which were also statistically similar with the treatment $T_5$. In case of efficacy percent, the rank of the treatments are as follows:

Tracer 45SC ($T_5$) (57.65%) >Vertimec 018EC ($T_6$) (51.64%) > Dr. Neem ($T_8$) (42.35%)> Proclaim 5SG ($T_3$) (36.36%) > Bikao ($T_7$) (32.73%) >Imitaf 20SL ($T_2$) (31.20%) > Fighter 2.5 EC ($T_4$) (25.00%). Therefore, after 1$^{st}$ spray Tracer 45SC was found as most effective treatment against leaf miner among tested bio pesticides as well as among all applied treatments followed by Vertimec 018EC and Dr. Neem while among the chemical insecticides Proclaim 5SG was most effective in controlling leaf miner. Present findings are also in line with the work of Ravipati et al. (2020) indicating that after first spray Spinosad exerted as next best superior treatment while Azadirachtin showed less efficacy than Spinosad.

After second spray the lowest mean number of larvae leaf$^{-1}$ was found with the treatment $T_5$ followd by $T_3$ and $T_6$ which was also on par with $T_5$ and these treatments were significantly superior to other treatments. Considering efficacy percent based on Number of larvae leaf$^{-1}$ the treatments followed the order as: Tracer 45SC ($T_5$) (81.97%) > Vertimec 018EC ($T_6$) (78.96%) > Proclaim 5SG ($T_3$) (76.67%) > Dr.

Neem ($T_8$) (69.67%) >Bikao ($T_7$) (63.03%) > Imitaf 20SL ($T_2$) (62.40%) > Fighter 2.5 EC ($T_4$) (58.50%).

From Table 3, it was observed that like previous two sprays all the tested treatments followed the similar pattern with third spray. In case of efficacy percent the rank of the treatments are as follows:

Tracer 45SC ($T_5$) (78.96%), Vertimec 018EC ($T_6$) (78.96%) > Proclaim 5SG ($T_3$) (73.30%) > Dr. Neem ($T_8$) (66.67%) > Bikao ($T_7$) (63.03%) > Imitaf 20SL ($T_2$) (57.80%) > Fighter 2.5 EC ($T_4$) (55.75%).

Table 3. Efficacy percent based on mean number of larva leaf $^{1}$ after 1st spray, 2nd spray and 3rd spray with different treatments

| Treatments | Pre count | After 1st spray | | After 2nd spray | | After 3rd spray | |
|---|---|---|---|---|---|---|---|
| | | Mean no. of larvae leaf$^{-1}$ | Efficacy percent | Mean no. of larvae leaf$^{-1}$ | Efficacy percent | Mean no. of larvae leaf$^{-1}$ | Efficacy percent |
| $T_1$ (Control) | 3.30 d | 5.55 a | -- | 7.11 a | -- | 7.77 a | -- |
| $T_2$ (Imitaf 20 SL)) | 5.00 a | 3.44 b | 31.20 | 1.88 b | 62.4 | 2.11 b | 57.8 |
| $T_3$ (Proclaim 5SG) | 3.30 d | 2.10 cd | 36.36 | 0.77 de | 76.67 | 0.88 e | 73.33 |
| $T_4$ (Fighter 2.5EC) | 4.00 b | 3.00 b | 25.00 | 1.66 bc | 58.5 | 1.77 c | 55.75 |
| $T_5$ (Tracer 45SC) | 3.66 c | 1.55 d | 57.65 | 0.66 e | 81.97 | 0.77 e | 78.96 |
| $T_6$ (Vertimec 018EC) | 3.66 c | 1.77 cd | 51.64 | 0.77 de | 78.96 | 0.77 e | 78.96 |
| $T_7$ (Bikao) | 3.30 d | 2.22 c | 32.73 | 1.22 cd | 63.03 | 1.22 d | 63.03 |
| $T_8$ ( dr. Neem) | 3.66 c | 2.11 cd | 42.35 | 1.11 de | 69.67 | 1.22 d | 66.67 |
| CV (%) | 2.84 | 12.25 | | 13.94 | | 8.38 | |
| LSD (0.05) | 0.18 | 0.57 | | 0.45 | | 0.30 | |

Same lettering in a column denotes statistical similarity among treatments whereas different lettering denotes statistically dissimilarity among treatments.

Table 4. Efficacy percent of different treatments based on percent leaf infestation

| Sl No | Treatments | Pre-Leaf infestation percent | After 1st spray | | After 2nd spray | | After 3rd spray | |
|---|---|---|---|---|---|---|---|---|
| | | | Percent (%) leaf infestation | Efficacy percent | Percent (%) leaf infestation | Efficacy percent | Percent (%) leaf infestation | Efficacy percent |
| 1 | $T_1$ (Control) | 35.55 | 47.27 a | -- | 58.26 a | -- | 61.68 a | -- |
| 2 | $T_2$ (Imitaf 20SL) | 27.77 | 24.51 bc | 11.74 | 23.90 b | 13.94 | 21.10 b | 24.02 |
| 3 | $T_3$ (Proclaim 5SG) | 37.78 | 25.20 b | 33.3 | 10.28 f | 72.79 | 9.65 f | 74.46 |
| 4 | $T_4$ (Fighter 2.5EC) | 30.55 | 25.84 b | 15.42 | 22.79 c | 25.41 | 16.75 c | 53.41 |
| 5 | $T_5$ (Tracer 45SC) | 34.22 | 21.69 d | 36.62 | 6.84 h | 80.01 | 7.99 g | 76.65 |
| 6 | $T_6$(Vertimec 018EC) | 36.23 | 23.13 cd | 36.16 | 9.58 g | 73.56 | 10.06 f | 72.23 |
| 7 | $T_7$ (Bikao) | 32.80 | 23.34 cd | 28.84 | 12.88 e | 60.73 | 13.53 e | 58.75 |
| 8 | $T_8$ (Dr. Neem) | 32.11 | 23.25 cd | 27.59 | 16.19 d | 49.58 | 15.75 d | 50.95 |
| | CV (%) | | 3.89 | | 2.24 | | 1.33 | |
| | LSD (0.05) | | 1.80 | | 0.77 | | 0.44 | |

Same lettering in a column denotes statistical similarity among treatments whereas different lettering denotes statistically dissimilarity among treatments.

Present results are partly in line with Variya and Patel (2012) who recorded lowest number of larvae leaf$^{-1}$ with emamectin benzoate while highest number of larvae with Imidacloprid after first spray. They also reported Spinosad and Emamectin benzoate as most effective insecticides against leaf miner after 2$^{nd}$ spray on Tomato while Imidacloprid as less effective insecticide.

Considering percent leaf infestation (Table 4), after first spray all the treatments showed significantly low leaf infestation percent compared to Control. Among the treatments, Tracer 45SC ($T_5$) treated plot showed lower leaf infestation percent while it was statistically similar with the treatments Vertimec 018EC ($T_6$), Bikao ($T_7$) and Dr. Neem ($T_8$). However, Imidacloprid 20Sl ($T_2$), Proclaim 5SG ($T_3$) and Fighter 2.5EC ($T_4$) had higher leaf infestation percent compared to Tracer 45SC ($T_5$). Actually, previous findings showed that Lamda cyhalothrin, as with other pyrethroids has a documented resistance against several agricultural pests (Rodriguez et al., 2001; Ahmad et al*.,* 2002) which may be the reason behind the less effectiveness of these pesticides. After second and third spray Tracer 45SC ($T_5$) was best effective treatment followed by Vertimec 018EC ($T_6$) and Proclaim 5SG ($T_3$).

Comparing of treatments performances based on percent leaf infestation among three sprays it was noticed that all treatments showed lower leaf infestation percentage after second & third sprays than first spray except untreated control which showed higher leaf infestation percent. Actually, first spraying of insecticides decreased the buildup of leaf miner population as well as oviposition resulted in comparatively lower larval population as well as percent leaf infestation in subsequent sprays.

Seal et al. (2002) reported Abamectin and Spinosyn as highly effective against leaf miner which confirmed this study. Mondol (2016) found Imidacloprid 17.8 SL moderately effective against leaf miner while emamectin benzoate less effective. As azadirachtin does not possess oviposition deterrent ability (Webb et al., 1983), Dr. Neem treated plots had significantly more infestation as compared to Tracer 45SC, Vertimec 018EC and Proclaim 5SG but the rates were significantly lower than untreated control. Devkota (2015) confirmed the obtained result indicating inability of Azadirachtin to work as feeding deterrent but ability to work as larvicide due to its high larvicidal property. The findings are also in line with Vietmeyer (1992) who mentioned that due to slow action of Neem insects continue to damage plants even after spraying resulting in higher infestation percentage.

In case of efficacy percent of treatments based on percent leaf infestation, after first, second and third spray Proclaim 5SG, Tracer 45SC and Vertimec 018 EC showed almost higher efficacy than other tested insecticides. After 3$^{rd}$ spray some variations occurred among other treatments and it is supposed that this varied efficacy percent was due to the impact of some biotic as well as abiotic factors such as parasitism, intraspecific competition, crop phenology, temperature and so on. Build up of Leaf miner population may be influenced by the effects of insecticides on natural enemies or amount of remained plant residue for the control of emerging adults. Moreover, several literatures indicated that depending on temperature insecticides efficacy may alter as temperature affects insecticidal toxicity by swaying volatility, stability, degradation and metabolism (An et al., 2020). Besides, temperature can also alter the behaviour of insects to insecticides (Xiong et al., 2019). Moreno (2009) also observed the varied efficacy of Abamectin in different seasons which is in line with the present result.

Some researchers have already documented development of resistance of *Liriomyza* species against Abamectin and Spinosad in other part of the world (Ferguson, 2004). Hernandez et al. (2011) reported harmful effects of Novaluron, Abamectin, Spinetoram and Lamda cyhalothrin against leaf miner parasitoids. It can be assumed that these insecticides may have detrimental effects on parasitoids or as these treatments also caused highest larval mortality there existed a little chance for parasitoids to parasitize larva or pupa of *Liriomyza.*

## Conclusion

Based on the results of the experiment it can be stated that three timely sprays of any one of these pesticides viz. Proclaim 5SG @ 1.0 g $L^{-1}$, Tracer 45SC @ 0.4 ml $L^{-1}$water and Vertimec 018 EC @ 1.2 ml $L^{-1}$ are capable to reduce the infestation of vegetable leaf miner and to keep a check on concerned pest for increasing crop yield. During pesticide selection the safety of the parasitoid guilds associated with this pest should be kept in mind. To delay the development of resistance against Spinosad, Abamectin and Emamectin it is recommended to use Bikao and Dr. Neem as alternative management options against leaf miner.

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